

REMARKS/ARGUMENTS

Favorable reconsideration of this application as presently amended and in view of the following remarks is respectfully requested.

Claims 1, 3, 9-12 and 14-18 are presently active in this case, and Claims 19-29 added by way of the present amendment.

In the outstanding Office Action, Applicant's election of Group I was acknowledged and Claims 9-11 and 16 were withdrawn from consideration; Claims 1, 3, 12, 14, 15, 17 and 18 were rejected under 35 U.S.C. 103(a) as being unpatentable over JP 10-317084 (JP '084) in view of JP 62-292244 (JP '244) or JP 5,311271 (JP '271), and further in view of U.S. 4,524, 821 to Berry et al.

First, Applicants wish to thank Examiner Kerns for the August 20th interview. During the interview, Applicants presented arguments substantially as indicated in this response. No agreement was reached with respect to the pending claims. Applicants also discussed narrowing the range of the recited heat formula, reciting specific heat temperatures, and reciting the crystalline and depth feature of withdrawn product Claim 9 in the context of a method and apparatus. Each of these additional features is recited in new dependent Claims 19-29, and a Request for Continued Examination (RCE) is filed herewith to ensure entry and consideration of Claims 19-29.

I. The Cited References Do Not, Either Alone or in Combination, Disclose All of the Features of Independent Claims 1 and 12.

Independent Claim 1 recites a continuous casting method for continuously manufacturing an aluminum or aluminum alloy metal cast member. The method includes driving a casting wheel, with a groove formed on an external peripheral surface thereof and

an endless belt put on the casting wheel so as to close the groove, in a direction of casting.

Also recited is causing the casting wheel and the endless belt to be differentiated in temperature therebetween at a portion of the endless belt where molten metal starts to come into contact with the endless belt. This causing includes heating the endless belt at a position before where the molten metal starts to come in contact with the endless belt such that said portion of the endless belt where molten metal starts to come into contact with the endless belt is heated to a temperature of ((melting point or liquidus-line temperature of the aluminum or aluminum alloy metal) \times 0.35) or above. The heating is performed by a heating device that is not configured to heat the molten metal, and the causing also includes cooling the casting wheel.

Thus, Claim 1 recites

“...heating the endless belt at a position before where the molten metal starts to come in contact with the endless belt **such that said portion of the endless belt where molten metal starts to come into contact with the endless belt is heated to a temperature of ((melting point or liquidus-line temperature of the aluminum or aluminum alloy metal) \times 0.35) or above... by a heating device...**” (emphasis added).

Claim 12 includes similar features in apparatus claim format.

As discussed in Applicants' specification, the purpose of heating the casting endless belt in the present invention is to cause a temperature gradient in the cast member to thereby shift the final solidification portion toward the endless belt side by increasing the temperature difference between the endless belt and the casting wheel to be cooled. The temperature regulation of the endless belt is very important to perform a highly precise solidification control. The temperature of the endless belt in operation slightly differs between when the endless belt is in contact with the molten metal and after the casting. Therefore, in the present invention, the temperature regulation of the casting endless belt is performed at the portion where the molten metal starts to come into contact with the endless belt to perform a

highly precise solidification control.¹ The reason why the casting endless belt is heated at a position before where the molten metal starts to come in contact with the endless belt is as follows. That is, in order to correctly set the belt temperature, it is advantageous to perform the heating at around the temperature regulation position than at a position distant from the temperature regulation position (see claim 15, Specification, page 8, lines 13-16, and Fig. 3).

The JP '271 reference does not disclose an endless belt apparatus, and thus does not disclose the above quoted feature of Claims 1 and 12. Further, the Office Action acknowledges that the JP '084 and JP '244 do not disclose heating of the endless belt by a heating device. However, the Office Action now cites Berry et al. as teaching this feature. Berry et al., discloses a casting band heater, which as seen in Fig. 2, includes a burner 250 positioned on the side of the band positioning roll 203 so that the endless belt is heated. As discussed in Berry et al., the purposes for heating the endless belt are:

- 1) to dry the endless belt, and
- 2) to attain a longer belt life for the endless belt by mitigating a difference between the temperature of the belt before coming into contact with the molten metal and the temperature of the belt in contact with the molten metal.

Thus, Applicants first note that these purposes of heating the endless belt in Berry et al. are apparently different from the purpose of the present invention in which the heating of the endless belt is performed to control the solidification of the molten metal.

Moreover, as shown in Fig. 2 of Berry et al., the burner 250 is positioned so that the endless belt is heated at the position distant from the contact start position where the endless belt starts to come into contact with the molten metal. In this configuration, the temperature of the endless belt is decreased from the heated temperature by the time the heated portion of the belt reaches the contact start position. Therefore, in a strict sense, Berry et al. fails to

¹ Applicants' specification, page 12, line 25 to page 13, line 9.

disclose the belt temperature at the time when the belt starts to come into contact with the molten metal. This portion is shown in Applicants' specification, for example, as Position R2 in Figure 3. That is, Berry et al. does not disclose "*heating the endless belt at a position before where the molten metal starts to come in contact with the endless belt,*" as recited in Claims 1 and 12.

Moreover, in view of these heating purposes in Berry et al. noted above, it is clear that the apparatus of this reference does not provide (or even require) strict temperature regulation for the solidification control of the molten metal. Thus, Berry et al. also does not disclose that the "portion of the endless belt where molten metal starts to come into contact with the endless belt is heated *to a temperature of ((melting point or liquidus-line temperature of the aluminum or aluminum alloy metal) x 0.35)* as recited in Claims 1 and 12.

In fact, the heating temperature by the burner 250 in Berry et al. is 190 to 245 °F (87.8 to 118 °C), which is far below the belt temperature required by Claims 1 and 12 of the present invention. Specifically, calculating the belt temperature according to the definition of "(melting point or liquidus- line temperature x 0.35 or above)," the belt temperature for A6061 alloy is $652\text{ }^{\circ}\text{C} \times 0.35 = 228.2\text{ }^{\circ}\text{C}$ or above ($442.8\text{ }^{\circ}\text{F}$ or above), and the belt temperature for copper is $1,053\text{ }^{\circ}\text{C} \times 0.35 = 379\text{ }^{\circ}\text{C}$ or above ($714\text{ }^{\circ}\text{F}$ or above). In this regards, it is also noted that the belt temperature in Berry et al. is not correlated with the melting point of the metal to be casted, in spite of the aforementioned purpose of prolonging the belt life by heating.

For the reasons discussed above, the cited references do not disclose all of the features of Claim 1 or Claim 12.

II. The Specification As Filed, Indicates Superior Results of the Claimed Invention.

In addition, the invention of Claims 1 and 12 is not obvious over JP '084, JP '244, and JP '271 when combined with Berry et al. As noted above, JP '084 does not differentiate temperature of the belt and casting member at all. While JP '271 and JP '244 discloses a difference in temperature, this is not achieved by heating the endless belt with a heating device, while cooling the casting wheel. Indeed, JP '271 does not even relate to an endless belt apparatus.

More specifically with respect the JP '244 reference, as discussed in the personal interview, the present invention relates to a combination of a cooled casting wheel and a heated endless belt. The temperature of the endless belt is specified based on a melting point or liquidus-line temperature of the aluminum or aluminum alloy so that a final solidification portion in which cast defects are generated is shifted on the belt side. An inverse segregation layer is formed in the belt side portion of the cast member, and therefore the belt side portion is inferior in quality. For this reason, it is desirable to remove the portion up to the depth of 2 to 3 mm at the belt side. The final solidification portion is formed at a further deeper portion. The final solidification portion is a portion to be removed.

In cutting the belt side portion of the cast material in a plane shape, the removable depth by a single cutting operation is about 5 mm. Removing the further deeper portion requires two or more cutting operations. That is, the inverse segregation layer can be removed by a single planar cutting operation, and the required number of cutting operations is decided by the position of the final solidification portion. If the depth to be cut is 10 mm or less, only two planar cutting operations are required; however, a depth of 12 mm will require three cutting operations, a depth of 17 mm will require four cutting operations etc. Thus, as also discussed in the interview, the greater the number of cutting operations, the more the production yield decreases.

The attached Exhibit 1 (Table) shows the casting conditions and final solidification portions of Example 2-1, Example 2-2, and Comparative Example shown in Table 1 of the specification of the present application as originally filed, as well as Example 1 and Example 2 of JP 62-292244. Further, the data of the cast member casted by heating the belt to 100 °C has been added as a Reference Example of the invention. The attached color Exhibits 2-5 (photos 1-4, respectively) are cross-sectional photographs of cast members casted in Example 2-1, Example 2-2, Comparative Example, and Reference Example of the invention. As discussed in the interview, the portions shown in red show final solidification portions (cast defect generated portions) to be removed to maintain the quality of the cast member.

In the Reference Example (Exhibit 5) of the present invention, the belt temperature is (liquidus-line temperature $\times 0.15$), and the depth of the final solidification portion is about 10 mm. Therefore, if the casting is performed at the belt temperature of (melting point or liquidus-line temperature) $\times 0.35$ as recited in the present invention, it is possible to assuredly form the final solidification portion at the depth of 10 mm or less. Therefore, there is a significant advantage to setting the belt temperature to (melting point or liquidus-line temperature) $\times 0.35$ or above. Specifically, the molten metal introduced into the groove formed on the external peripheral surface of the casting wheel will solidify and contract in the peripheral direction. For this reason, the casting material which is being solidified is pressed against the groove of the casting wheel, enhancing the heat-transfer between the casting material and the casting wheel, which facilitates the solidification of the wheel side portion. On the other hand, a gap will be generated between the endless belt and the casting metal, causing deteriorated heat-transfer of the belt side portion, which delays the solidification of the belt side portion of the casting material. In other words, the structure including the casting wheel and the casting endless belt is advantageous in shifting the final solidification portion toward the belt side. Thus, with the claimed invention, fewer planar cutting operations are

required to remove the defect portion, thereby providing improved throughput, and improved yield.

On the other hand, Example 2 of JP 62-292244 shows a copper casting in which the belt temperature is heated to 200 °C. The belt temperature of 200 °C equals to (copper liquidus-line temperature x 0.18) and corresponds to the belt temperature of 120 °C (652 °C x 0.18) in the case of aluminum, which is lower than the belt temperature as defined by the present invention. JP 62-292244 reads that the depth of the final solidification portion is 3 mm (depth/thickness of the cast member 0.1). However, copper is better than aluminum in thermal conductivity [copper thermal conductivity: 398 W/(m K); aluminum thermal conductivity: 237 W/(m K)]. Therefore, a temperature gradient is hardly generated in copper. For this reason, it is hardly believed that the final solidification is shifted on the belt side as disclosed under the disclosed casting conditions.

Further, in Example 2 of JP 62-292244, a flat-type casting die is used. In this case, a gap is formed between the casting die and the casting material when the molten metal solidifies and contracts, deteriorating the thermal transfer between the casting metal and the casting die, which in turn causes delayed solidification on the casting die side. For this reason, judging from the structure of the casting die, it is not considered that the final solidification portion can be shifted toward the belt side as provided by the invention as claimed in Claims 1 and 12. Thus, the claimed invention provides an advantage in that fewer planar cutting operations are required to remove the defects, which results in higher yield as noted above.

The product yield may be even further improved in accordance with the present invention. In the claimed structure in which the casting wheel is cooled and the endless belt is heated, the casting material is cooled from the side walls of the casting die. Therefore, the final solidification portion is formed in the widthwise center, and the temperature gradient in

the width direction increases as the belt temperature increases. Thus, the final solidification portion gathers in the center. As shown in Exhibits 1 through 4, as the belt temperature increases, the final solidification portion not only shifts to the belt side, but also gathers in the widthwise center. In cases where the final solidification portion is gathered at the center portion, the yield ratio can be enhanced by minimizing the cutting amount.

More specifically, in the illustrated cast material shown in the attached Exhibit 6 (drawing), the center of the final solidification portion is located at the depth of 5 mm, and the depth to be removed is 10 mm. When removing the final solidification portion of this cast material by planner cutting, it is required to perform cutting operations twice to remove the portion up to the depth of 10 mm. However, where the final solidification portion is concentrated, the final solidification portion can be removed by performing a V-shape cutting after performing a 5 mm depth planner cutting. This advantage is disclosed in Applicants specification as originally filed.² More precisely, however, the yield ratio when performing two planner cutting operations is 75.3%, and the yield ratio when performing a single planner cutting operation and then performing a V-shape cutting of a required portion is 85.6%. For information, the yield ratio when performing a planner cutting operation up to the depth of 15 mm is 63.5%.

By contrast, JP 62-292244 discloses Example 2 in which the endless belt is heated to 200 °C and the side walls are heated to 200 °C. Thus, the temperature gradient in the width direction is small and the final solidification portion would not gather in the center but would actually expand in the width direction. As a result, the area to be removed increases, resulting in deteriorated yield ratio.

In the present invention, in the structure in which the casting wheel is cooled and the endless belt is heated, the belt temperature is set to (melting point or liquidus-line

² Applicants published specification at paragraph [0072].

temperature) x 0.35 or above to thereby shift the final solidification portion toward the belt side and gather the final solidification portion in the widthwise center. This results in a minimum removal amount. Such effect cannot be obtained by simply setting the belt temperature. Still more, if the side walls of the casting wheel are heated as taught by JP 62-292244, the area to be removed is increased, which deteriorates the yield ratio.

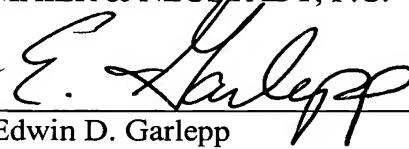
Accordingly, it would not be obvious for one of ordinary skill in the art to conceive the belt temperature as recited in the present invention in view of JP '244 and JP '271. Furthermore, even if the teachings of JP '244 and JP '271 are applied to the continuous casting method of JP '084, the belt temperature of the present invention would not have been realized.

As discussed above, the present invention includes specific structural features which are not conceived by the combination of JP 10-317084 disclosing a continuous casting device using a casting wheel and an endless belt, JP 62-292244 and JP 5-311271 in which casting surfaces are set to be different in temperature, and Berry et al. disclosing the heating of the endless belt. Therefore, independent Claims 1 and 12 patentably define over the cited references. Furthermore, since Claims 3, 9-11 and 14-18 depend directly or indirectly from Claim 1 or Claim 12, substantially the same arguments set forth above also apply to these dependent claims. Hence, dependent Claims 3, 9-11 and 14-18 are believed to be allowable as well.

Consequently, in view of the present response, no further issues are believed to be outstanding in the present application, and the present application is believed to be in condition for formal Allowance. An early and favorable action is therefore respectfully requested.

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,
MAIER & NEUSTADT, P.C.

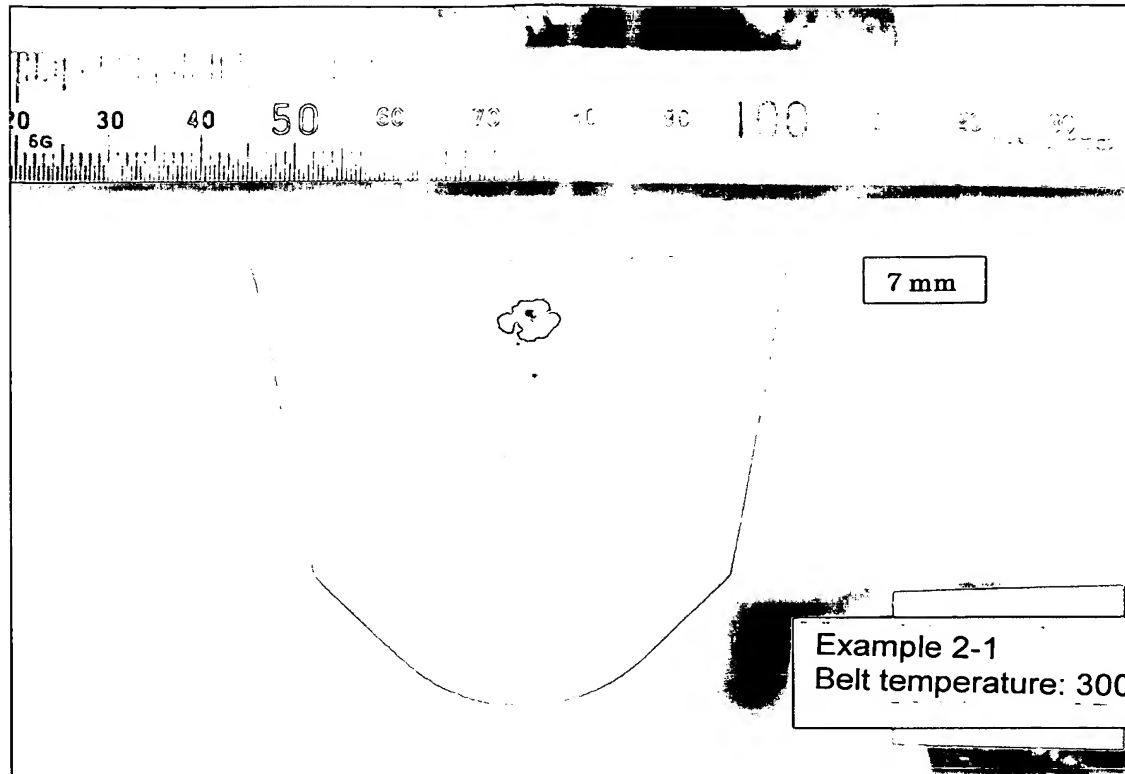
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Attorney of Record
Registration No. 45,330

	Casting metal	Continuous belt		Casting wheel	Final solidification portion position in caster member		Cross-sectional photo
		Temp.	Belt temp./melting point or liquidus-line temp.		Depth from the surface	Depth /cast member height	
Example 2-1	A6061	300 °C	0.46	Water cooling	7 mm	0.13	Photo 1
Example 2-2	A6061	500 °C	0.77	Water cooling	5 mm	0.09	Photo 2
Comparative Example	A6061	Cooling	0.076	Water cooling	15 mm	0.27	Photo 3
Reference Example	A6061	100 °C	0.15	Water cooling	10 mm	0.18	Photo 4
Example 1	Copper	Natural cooling	Unknown	Bottom wall: water cooling Side wall: natural cooling	6 mm	0.2	
Example 2	Copper	200 °C	0.18	Bottom wall: water cooling Side wall: 200 °C	3 mm	0.1	
Present invention							
JP 62-292244							

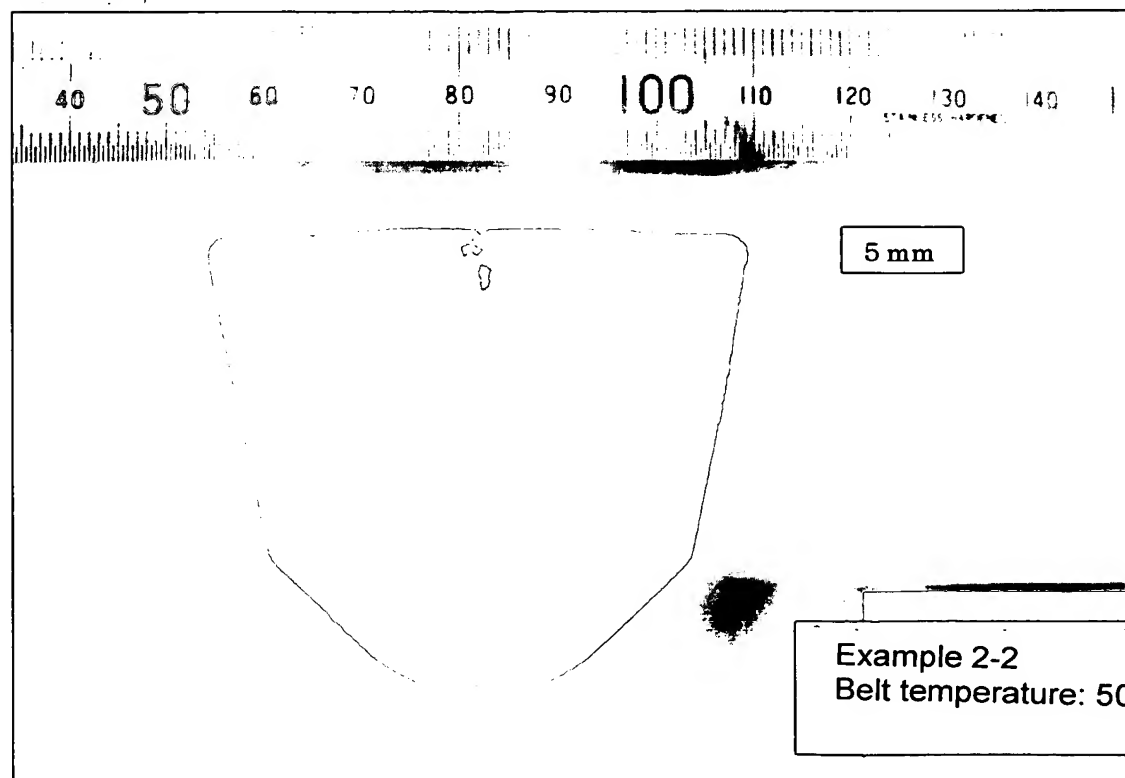
(Continuous belt) Casting metal of the invention: JIS A6061' the liquidus-line temperature: 652 °C (Specification, page 16, line 19)
 "Cooling" in the Comparative Example of the present invention was calculated at 50 °C
 Casting metal of JP 62-292244: calculated by assuming that the melting point of copper was 1,083 °C
 (Height of cast member) Invention: 55 mm (Specification, page 16, line 22), JP 62-292244: 3 cm (page 3, left lower column)

Photo 1



Example 2-1
Belt temperature: 300 °C

Photo 2



Example 2-2
Belt temperature: 500 °C

Photo 3

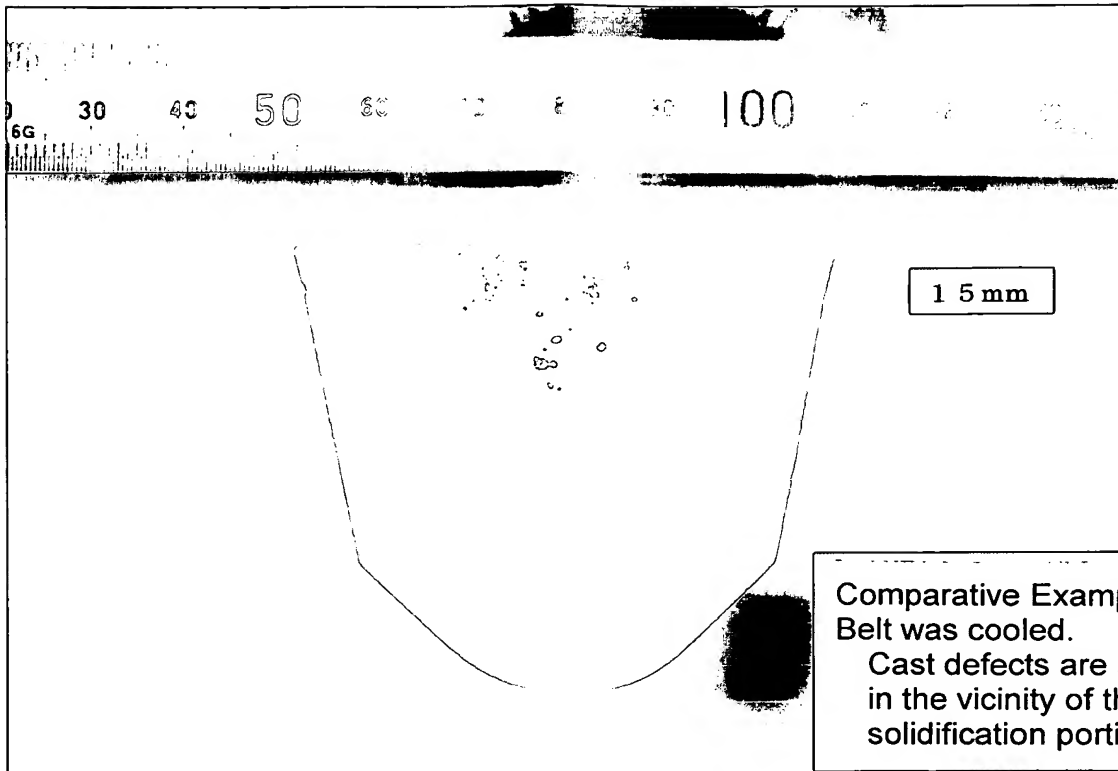
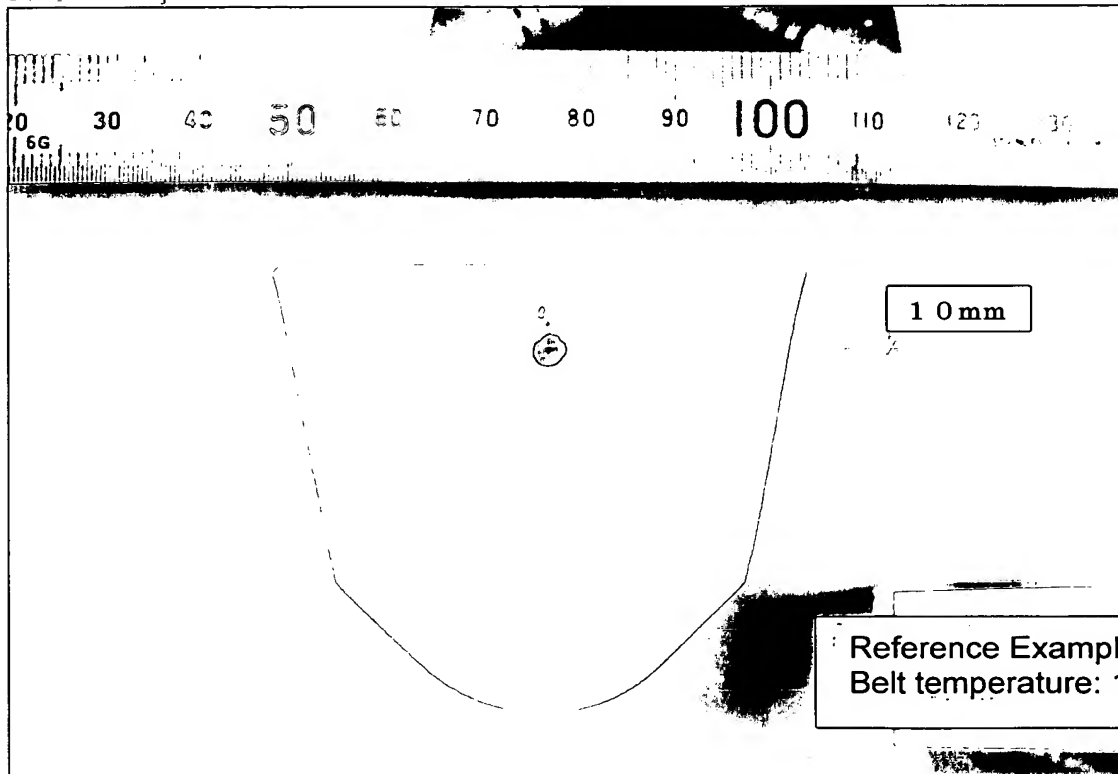
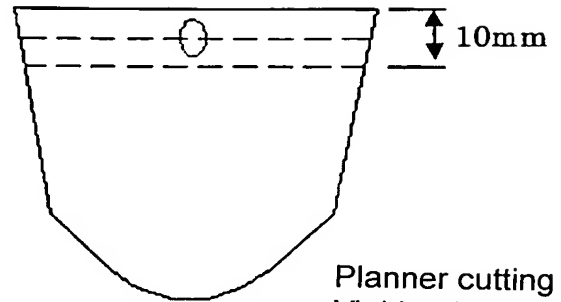
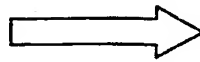
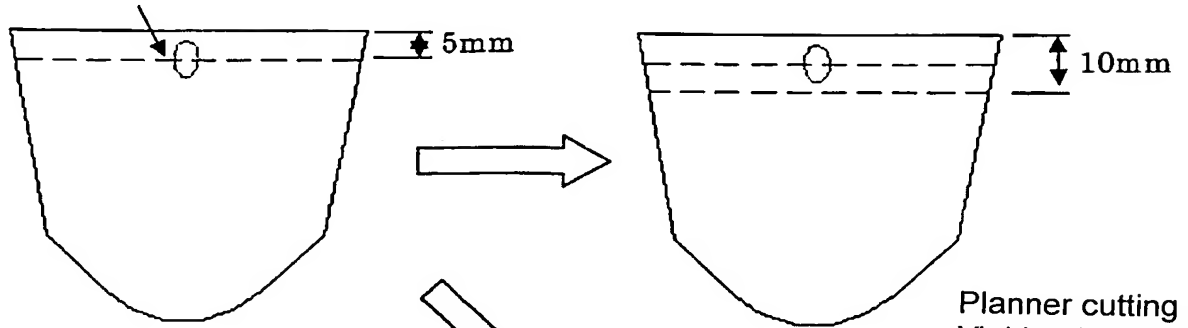


Photo 4

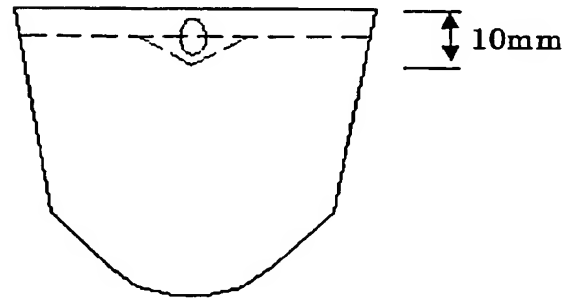
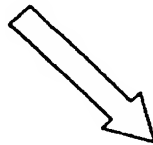


Drawing

Final solidification portion (cast defect generated portion)



Planner cutting example
Yield ratio: 75.3%



V-shape cutting example
Yield ratio: 85.6%